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Micronutrient intake and food sources in the very old: Analysis of the Newcastle 85+ Study

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Abbreviations: 24hr-MPR, 24 hour multiple pass recall; CCP, cereals and cereal products; DRV, Dietary Reference Value; EAR, Estimated Average Requirement; LRNI, Lower Reference Nutrient Intake; NDNS, National Diet and Nutrition Survey; NMES, non-milk extrinsic sugars; RNI, Reference Nutrient Intake.

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Abstract

A number of socioeconomic, biological and lifestyle characteristics change with advancing age and place very old adults at increased risk of micronutrient deficiencies. The aim of this study was to assess vitamin and mineral intake and respective food sources in 793 eighty-five year-olds (302 men and 491 women) in the North-East of England, participating in the Newcastle 85+ Study. Micronutrient intakes were estimated using a multiple pass recall tool (2x24hr recalls). Determinants of micronutrient intake were assessed with multinomial logistic regression. Median vitamin D, calcium and magnesium intakes were 2.0 (IQR:1.2-6.5) µg/day, 731 (IQR:554-916) mg/day and 215 (IQR:166-266) mg/day, respectively. Iron intake was 8.7 (IQR:6.7-11.6) mg/day and selenium intake was 39.0 (IQR:27.3-55.5) µg/day. Cereals and cereal products were the top contributors to intakes of folate (31.5%), iron (49.2%) and selenium (46.7%) and the second biggest contributors to intakes of vitamin D (23.8%), calcium (27.5%) and potassium (15.8%). More than 95% (n=756) of the participants had vitamin D intakes below the UK's Reference Nutrient Intake (10 µg/d).. Twenty percent or more of the participants were below the Lower Reference Nutrient Intake for magnesium (n=175), potassium (n=238) and selenium (n=418) (comparisons to dietary reference values (DRVs) do not include supplements). Since most DRVs are not age-specific and have been extrapolated from younger populations, results should be interpreted with caution. Participants with higher education, from higher social class and more physically active had more nutrient-dense diets. More studies are needed to inform the development of age-specific DRVs for micronutrients for the very old.

Key words: dietary intake, vitamins, minerals, 'aged, 80 and over', Newcastle 85+

Introduction

A number of socioeconomic, biological and lifestyle characteristics change with advancing age and place very old adults (those aged 85 years and over) at increased risk of micronutrient deficiencies. For example, 10-30% of older adults (aged 65 and over) have atrophic gastritis and hypochlorhydria[1] which reduces secretion of acid-pepsin and intrinsic factor allowing small bowel bacterial growth and leading to impaired vitamin B12 absorption[2]. Although micronutrient malabsorption is not an inherent consequence of ageing, the absorption of pH-dependent vitamins and minerals, such as folate, vitamin B12, calcium, iron and β-carotene might be partially compromised[1,3]. Very old adults are also at higher risk of vitamin D deficiency due to reduced skin stores of 7-dehydrocholesterol (provitamin D), renal impairment and reduced renal conversion of its biologically inert to active form (i.e. 25-hydroxyvitamin D to calcitriol), immobility, malnutrition and environmental factors [reviewed in Hill *et al.*[4]]. Micronutrient deficiencies may contribute to disability, frailty and impaired physical function in very old adults[5].

In the United Kingdom (UK), apart from the Reference Nutrient Intake (RNI) for vitamin D which sets a Dietary Reference Intake (DRV) for people aged 65 and over, all other DRVs for vitamins or minerals apply equally to everyone aged ≥50[6]. The scarcity of dietary data on very old adults, and lack of evidence for relationships with risk factors and health outcomes, have resulted in DRVs based on extrapolations from younger populations[7].

The 1994-95 National Diet and Nutrition Survey (NDNS) of people aged 65 and over identified a significant number of older adults with inadequate micronutrient intakes, namely vitamin D, magnesium and potassium[8]. A review of micronutrient intakes across Europe revealed that inadequacy (assessed against the Nordic Nutrition Recommendations, estimated average intake) was present in more than 20% of older adults (≥65 years) for vitamin D, folate, calcium and selenium[9]. Similarly, a review of non-institutionalised older adults living in western countries concluded that at least 30% were below the Estimated Average Requirement (EAR) for vitamin D, vitamin B2, calcium, magnesium and selenium[10].

The aim of this study was to assess daily energy, vitamin and mineral intakes of 85 year olds participating in the Newcastle 85+ Study; determine its food sources; compare intakes with the current UK DRVs; and explore socioeconomic and lifestyle determinants of micronutrient intake.

Methods

Newcastle 85+ Study

The Newcastle 85+ Study is a longitudinal population-based study of health trajectories and outcomes of a cohort of 852 very old people (85 years old at baseline) born in 1921 (for details visit http://research.ncl.ac.uk/85plus)[11-13]. Complete dietary intake data (without protocol violation) was available for 793 participants (302 men and 491 women).

Dietary assessment, micronutrient estimation and supplement use

Dietary intakes were collected using a 24h Multiple Pass Recall (24hr-MPR) tool on two distinct occasions (one week apart and on different days of the week) at baseline (2006/2007) by trained research nurses in the participant's usual residency. Food and drink portion sizes were estimated with the "Photographic Atlas of Food Portion Sizes"[14]. All dietary intake data were independently double entered. Any discrepancies were identified, checked against original records and corrected prior to data analysis. Energy, vitamin and mineral intakes were estimated using the McCance and Widdowson's sixth edition food composition tables (used as published)[15] together with a purpose-designed in house Microsoft Office Access database on the nutrient composition of commonly consumed foods [16]. Eighty five percent and 90% of the participants believed that the 24hr-MPRs reflected their usual food and drink intake, respectively. Intakes of energy, vitamin A, β-carotene, vitamin B2, vitamin B6, folate, vitamin B12, vitamin E, vitamin C, vitamin D, calcium, iron, magnesium, potassium, sodium, selenium and zinc are reported here (excluding supplements). Vitamin and mineral density per 1 MJ of energy was also calculated.

Supplement use was divided into three categories viz. no supplements, one supplement and, two or more supplements. Information on supplement use was limited to type and brand, therefore micronutrient-containing supplements were assumed to be taken according to manufacturer's specifications. Supplement users were characterised by supplement type: those taking fish and omega-3 oil preparations, single mineral/vitamin preparations, multivitamin and/or multimineral preparations and, other supplements. Micronutrient intakes from all sources (including supplements) and the difference (%) between micronutrient intakes from dietary sources only (excluding supplements) were determined but supplements were not included in the main analysis.

Food groups

Individual foods were coded and allocated to food groups. Briefly, individual foods were allocated to 15 first level food groups: cereals and cereal products, milk and milk products, eggs and egg dishes, oils and fat spreads, meat and meat products, fish and fish dishes, vegetables, potatoes, savoury snacks, nuts and seeds, fruit, sugar, preserves and confectionery, non-alcoholic beverages, alcoholic beverages and miscellaneous [16]. The average contribution of food groups to vitamin and mineral intakes was reported so that ≥90% of intakes were explained.

Estimation of misreporting

The proportion of possible misreporters was calculated using a EI:BMR cut-off of 1.05-2.00 (further details can be found in Mendonça *et al*.)[16]. With this cut-off, 26.3% were identified as misreporters (21.6% as under-reporters and 4.7% as over-reporters). Possible misreporters have not been excluded from the analysis because of the uncertainty surrounding this estimate and the small differences observed between excluding and not excluding misreporters[16]. Further, in 5% of the participants (n=42) the proxy was the only respondent.

Socioeconomic, health and lifestyle factors

Apart from supplement use, details on other socioeconomic and lifestyle variables have been previously published[11] and commented on the companion paper: Dietary intake and food sources in the very old: Analysis of the Newcastle 85+ Study[16]. Participants were classified according to housing: standard, sheltered or institutional housing. Further, participants were characterised as living alone, with spouse or with others, years of full-time education (categorised as nine or less/ 10-11/ and 12 or more years) and social class according to the National Statistics Socio-Economic Classification (NS-SEC) three class scheme[17]. Participants were also categorised into those with low (scores 0-1), medium (scores 2-6) and high (scores 7-18) physical activity based on a validated and purpose designed physical activity questionnaire[18].

Statistical analysis

The Shapiro-Wilk test and Q-Q plots were used for normality testing. Normally distributed data are reported as means and standard deviations (SD), and non-normal data as medians and interquartile ranges (IQR). Baseline characteristics, micronutrient intake and percentage of participants below the Lower Reference Nutrient Intake (LRNI), EAR, RNI and UL were

calculated using descriptive statistics. If available, LRNI was the preferred DRV to be reported. The LRNI is only supposed to meet the needs of 2.5% of a given population and intakes below this are likely to be "inadequate". When appropriate, sex differences were assessed with two sample t-test or chi-squared test ($\chi 2$) for normally distributed continuous variables and categorical variables, respectively. Most micronutrient intake data were continuous and non-normally distributed therefore, sex differences were determined by the Mann-Whitney U test. Vitamin and mineral intakes were stratified by housing, living arrangements (with whom participants lived), years of full time education, social class [coded to the National Statistics Socio-economic Classification (NS-SEC) 3 class system[17]] and physical activity groups and compared by multinomial logistic regression. Apart from energy, which was adjusted for gender only, all vitamins and minerals were adjusted for gender and energy. Exploratory and statistical analyses were conducted using the IBM statistical tool SPSS v22.0. Values of $P<0.05$ were considered significant.

Results

Vitamin intakes

Men had higher vitamin intakes than women except for vitamin C (Table 2). However, the overall higher vitamin intake by men disappeared when the results were expressed per 1 MJ. Specifically, women's vitamin A intake was 12 µg-RE/MJ or 13% higher (p=0.008) and vitamin C intake was 20 mg/MJ or 28% higher (p=0.001) than men's intake. Despite 43% of participants (n=335) consuming one or more supplements on a regular basis (Table 1), on a population level, vitamin intakes changed only marginally when supplements were included except for vitamin A and D which increased by 19.2% (from 620 to 752 µg-RE) and by 22.5% (from 2.0 to 2.5 µg), respectively (supplementary Table 1). Due to the modest differences to micronutrient intake when including supplements, and limitations in supplement frequency data, micronutrient consumption from supplements was not included in the main analysis.

Vitamin food sources

Figure 1 shows the percent contribution of food groups to vitamin intake for all participants. Forty percent of vitamin A intake was contributed by meat and meat products - the majority coming from liver and liver products and dishes (94.4%). Vegetables were the second biggest contributor (22.4%) to vitamin A intake, of which most came from carrots (71.1%). Cereals and cereal products (CCP) were the biggest contributors (31.5%) to folate intake, 86.9% of which came from bread and breakfast cereals. Vegetables were the second biggest contributor (15.8%) to folate intake with 42.4% coming from cruciferous vegetables. Half (49.6%) of the vitamin B12 intake from meat and meat products (52.3%) came from liver and liver products and dishes. One third (33.8%) of vitamin D intake came from fish and fish dishes (98.9% of which was from oily fish), and 23.8% from CCP (45.2% of which was from breakfast cereals and 43.3% from buns, cakes, pastries and fruit pies).

Mineral intakes

Similar to vitamin intake, men had an overall higher mineral intake than women (24% higher on average) (Table 2). When expressed per 1 MJ of energy, men still had higher intakes of iron (p=0.005), selenium (p=0.028) and zinc (p<0.001) compared to women but lower calcium intakes (p=0.008). On a population level, supplement contribution to mineral intakes was almost negligible (supplementary Table 1). The highest difference between dietary intake with and without supplements was only 2.7% for zinc (from 7.1 to 7.3 mg).

Mineral food sources

Figure 1 shows the percent contribution of food groups to vitamin intakes for all participants. Milk and milk products were the biggest contributors (31.3%) to calcium intake while CCP was second with 27.5% (36.6% of which came from bread). Non-alcoholic beverages contributed 18.9% to calcium intake mainly because tea and coffee (with added milk) were included in this group (95.4% came from tea, coffee and water). Non-alcoholic beverages accounted for 19.0% of potassium intake (81.5% of which was from tea, coffee and water). CCP (15.8%) and potatoes (14.6%) were the second and third, respectively, biggest contributors to potassium intake. CCP explained 46.7% of selenium intake, and 93.2% of this came from bread. Meat and meat products made a higher contribution to intakes of iron (19.3% vs. 14.2%), vitamin D (20.3% vs. 13.4%) and vitamin B12 (59.2% vs. 47.8%) for men than for women (data not shown).

Micronutrient adequacy

The failure of both men and women in the Newcastle 85+ Study to meet several micronutrients' DRVs was widespread (Figure 2 and Supplementary Table 2).. Twenty percent of the participants had intakes below the LRNI for magnesium, potassium and selenium. The proportion of participants below the LRNI for vitamin A, vitamin B12 and zinc was around 10%. However, 4.6% (n=36) of the participants had vitamin A intakes above the UL. The widest disparity between intake and recommendations was seen for vitamin D intake, with more than 95% (n=756) of participants having intakes below the RNI for vitamin D of 10 µg per day (EAR or LRNI for vitamin D have not been defined for the UK)[6] and 52.7% (n=418) of participants were below the LRNI for selenium. In contrast, 82.2% (n=652) of participants were above the RNI for sodium of 1600 mg per day[6]. The 95th percentile of sodium intake was 4663 mg per day and within those that were above the RNI, median intake was 2594 mg. Fewer men had intakes below the DRV for vitamin B12, iron, potassium and folate than women. The widest difference between men and women not meeting the LRNI was for vitamin B12 (5.0% vs. 12.4%, $p<0.001$) and iron (2.3% vs. 7.8%, $p<0.001$). Meat and meat products were top contributors for both these micronutrients.

Micronutrient intake by housing, SES and physical activity

Table 3 reports the energy, vitamin and mineral intakes in the Newcastle 85+ Study stratified by housing, living arrangements, years of full time education, social class (past occupation

according to NS-SEC) and physical activity. All micronutrients were adjusted for gender and food energy intake.

Energy and vitamin D intake were higher in participants who lived in institutional care (nursing or residential) than in standard housing. Conversely, vitamin E, magnesium and potassium intakes were lower in institutional than in standard housing. Participants who lived with their spouses had higher potassium and selenium intake than those who lived alone. Those with 12 or more years of full time education had higher intakes of vitamin C, vitamin D, calcium, magnesium and potassium than those with ≤ nine years of full time education. Social class also predicted the intake of several vitamins and minerals. Participants with previous higher managerial, administrative and professional occupations (class 1) had higher intakes of vitamin B2, folate, calcium, iron, magnesium, potassium and zinc than those who had routine and manual occupations (class 3).. Those with high physical activity had a more nutrient-dense diet in vitamin B6, folate, vitamin E, vitamin C, iron, magnesium, potassium and zinc than those with lower physical activity.

Discussion

. Median vitamin D, magnesium, potassium and selenium intake was 2.0 (IQR:1.2-6.5) µg/day, 215 (IQR:166-266) mg/day, 2477 (IQR: 1890-3023) mg/day and 39.0 (IQR:27.3-55.5) µg/day, respectively. Participants that spent more full-time years in education, were from higher social class and were more physically active had more nutrient-dense diets in several vitamins and minerals. The most notable finding is that 20% or more of the participants in the Newcastle 85+ Study had intakes below the LRNI for magnesium, potassium and selenium and that more than 95% of participants were below the RNI of 10 µg/day of vitamin D. Very old adults may be at increased risk of micronutrient deficiencies, which contributes to disability, frailty and loss of physical function[5]. Therefore, a deeper understanding of the dietary habits of the very old is an important prerequisite for developing evidence based, age-specific dietary recommendations.

Comparison with other studies

Since the 1994-95 NDNS of people aged 65 and over, which included 172 men and 287 women aged 85 and over (all non-institutionalised), no study has described micronutrient intakes and food sources in a large sample of very old adults in the UK. Most vitamin and mineral intakes were similar between the two studies except for β-carotene (1141 vs. 1516 µg/day), vitamin C (41.4 vs. 56.5 mg/day) and calcium (644 vs. 731 mg/day) which were higher in the Newcastle 85+ Study participants (intakes from food sources only)[19]. In the 1994-95 NDNS, less vitamin A (34% vs. 40%) and vitamin B12 (43% vs. 53%) were derived from meat and meat products and less potassium from non-alcoholic drinks (10% vs. 19%). However, more vitamin B12 (29% vs. 13%), calcium (54% vs. 31%) and potassium (20% vs. 9%) came from milk and milk products in the 1994-95 NDNS than in the Newcastle 85+ Study. The food sources of vitamin D were considerably different between the studies with fish and fish dishes making a lower contribution to intake (17% vs. 34%) while fat spreads made a higher contribution (23% vs. 8%) in the 1994-95 NDNS than in our study[19]. The observed differences are unlikely to be due to fortification policies. The Newcastle 85+ Study included 85 year olds only while the 1994-95 NDNS included those aged 85 and over. Other possible reasons include different dietary assessments (4-d weighted diet record vs. 2x24hr-MPR) that diverged by more than a decade.

The European Prospective Investigation into Cancer and Nutrition (EPIC)-Oxford third follow-up questionnaire in 2010-2014 included 411 men and 872 women aged 80 and over[20]. Intakes of all vitamins and minerals were at least 20% higher in the EPIC-Oxford than in the Newcastle 85+ Study participants (personal communication with Professor Tim Key and Dr. Paul Appleby). Different descriptive statistics and dietary assessment methods used, different ages (≥80 vs. 85 year olds) and

characteristics of the participants (14% of EPIC-Oxford participants were vegetarians) are potential explanations for the wide differences observed in micronutrient intake.

The current NDNS rolling programme (from 2008/2009 to 2011/2012 or years 1 to 4) does not yet have enough very old adults for comparison with our study. Nonetheless, it included 428 adults (191 men and 237 women) aged ≥65[21]. Although energy intakes were similar between both studies, vitamin and mineral intakes (without supplements) were slightly higher in the NDNS than in the Newcastle 85+ Study (except for sodium where intakes were 1947 and 2383 mg/day, respectively). More than 10% of the participants had intakes for magnesium, potassium and selenium below the LRNI[21]. Similarly, >20% of the Newcastle 85+ Study participants were also below the LRNI for these minerals.

Public health implications

In the Newcastle 85+ Study, men had higher energy intakes than women therefore, it was not unexpected that intakes of most micronutrients by men were also higher. However, when vitamin and mineral intakes were expressed per 1 MJ, vitamin A, C and calcium were higher in women than in men. Conversely, men's diets were more nutrient-dense in vitamin B12, iron and selenium than women's. Higher meat and meat products consumption by men was the main driver for these differences.

Several micronutrient intakes were lower than the current DRVs. Twenty percent or more of the participants were below the LRNI for magnesium, potassium and selenium while 95.3% were below the RNI for vitamin D [the Scientific Advisory committee tentatively set the same RNI as the Committee on Medical Aspects of Food and Nutrition Policy[22]]. This is of concern because magnesium is associated with physical performance[23], systemic inflammation, endothelial function[24] and bone mineral density in older adults[25]; inadequate selenium has been linked with anaemia[26], cancer and all-cause mortality[27]; and low Vitamin D intake has consistently been associated with musculoskeletal[4] and extra-skeletal outcomes including cognitive impairment and mortality[28,29]. However, the major "inadequacy" in vitamin D intake may not reflect vitamin D status since circulating concentrations of 25-hydroxyvitamin D depend largely on sun exposure[4]. Higher potassium intakes are a known protective factor for hypertension[30] whereas excessive sodium intake is an established risk factor for hypertension in older adults[31]. In our study, only a fifth of the participants were below the RNI of 1600 mg per day of sodium but half met the recommendation of less than 2400 mg per day. Sodium intake reduction and increased potassium intake might help reduce the prevalence of stroke and fatal coronary heart disease in this population[32].

More than 10% of participants had vitamin A intakes below the LRNI but, interestingly, 5% had intakes above the upper level (UL) of 3000 µg-RE per day set by the European Food Safety Authority

(EFSA)[33]. This classic paradox may not be the result of habitual intake, but the result of consuming high vitamin A content foods (e.g. liver and liver dishes) on one or more of the non-consecutive 24h recalls of the 24hr-MPR[34]. In fact, 35 out of the 36 participants who had vitamin A intakes above the UL of 3000 µg-RE ate liver and liver products at least on one of the 24hr-MPR.

Assessing micronutrient intake inadequacies in this age group has several methodological limitations. Twenty-seven percent (n=214) of the participants were classified as cognitively impaired (Standardized Mini-Mental State Examination ≤25) (data not shown) which might have played a major part in misreporting (estimated to be 26.3%). Further, due to a scarcity of nutrition data in this age group, most DRVs were extrapolated from younger populations. This leads to uncertainty regarding the health significance of inadequacies in the very old.

In line with previous studies[35] and a recent review on socioeconomic determinants of micronutrient intakes in older adults[36], participants with more education and from a higher social class had overall higher micronutrient intakes. Similarly, perhaps because healthy habits cluster together, those who were more physically active had more nutrient dense diets. It has been argued that nutrient-dense foods are more expensive than less healthy foods in the UK and United States of America (USA)[37,38] and this price differential might explain the difference in nutrient density between lower and higher socio-economic (SES) groups. However, others have challenged the view that healthier foods or dietary patterns are more expensive than unhealthy ones and e.g. price differentials are dependent on the unit of comparison (e.g. per calorie, per mass)[39,40]. Physical proximity to (and/or means to access) fresh-produce stores has been proposed as an explanation for higher micronutrient intakes in high SES groups[41] but this is somewhat debatable in the UK and North-East England[42]. Inaccessibility to fresh produce, higher cost of nutrient-dense foods in the UK and poorer food choices[43] are some of the potential causes that mediate the diet quality gradient between SES groups. In this age group, with more disabilities and lower income, these issues might be exacerbated.

Strengths and Weaknesses

The Newcastle 85+ Study was socio-demographically representative of the general UK population. However, all participants were from Newcastle-upon-Tyne and North Tyneside and of a predominantly white background which can limit generalisations[16]. Thirty-five percent of the 24hr-recalls were performed during summer (June-August) while the rest were evenly distributed throughout the other three seasons. Seasonality is known to influence micronutrient intake but the slight bias towards summer is unlikely to have changed the results. Although vitamins and minerals are not abundantly present in commonly underreported foods, such as sweets and snacks, the inherent retrospective nature of the 24hr-MPR might have proved challenging for some individuals in this age

group. Adamson *et al* have described in detail the challenges of dietary assessment in this age group and in the pilot study[44]. To reduce patient and interviewer burden, only qualitative data on supplement use were collected. Therefore, the frequency of supplement use had to be estimated based on the manufacturer's recommendations. Data on sodium derived from table salt and salt used in cooking was not recorded which might have underestimated sodium intake in the Newcastle 85+ Study.

Conclusion

Food sources of the selected micronutrients in the Newcastle 85+ Study were diverse but, because cereals and cereal products were widely consumed, they were among the top contributors to intakes of several vitamins and minerals. Higher SES and greater physical activity were associated with higher micronutrient intakes. Compared to current DRVs, several micronutrient intakes were "inadequate" and selenium (52.7% below the LRNI) and vitamin D (95.3% below the RNI) showed the greatest disparities. However, the lack of evidence-based, age-specific DRVs for micronutrients for the very old means that such information should be interpreted with caution. Because energy requirements are dependent on energy expenditure, the decrease in energy needs in later life mirrors the age-dependent fall in physical activity. However, the physiological basis for age-dependent changes in vitamin and mineral requirements (if any) is poorly understood. In the absence of such evidence, it may be appropriate that dietary information for very old people focuses on healthy food choices, on increasing nutrient density and only recommending the use of supplements in specific situations [45].

In summary, this study provides novel insights into micronutrient intakes, their corresponding food sources and the sociodemographic and lifestyle determinants of micronutrient intakes in very old people. Given the dearth of dietary intake data in the very old, the contemporary micronutrient data from our study are likely to be the most reliable for this age group in the UK. The findings will need to be confirmed in other cohort studies of the very old.

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paper, commented and approved the final manuscript. None of the authors reported any conflict of interest.

References

1. Johnson MA (2007) If high folic acid aggravates vitamin B12 deficiency what should be done about it? *Nutr Rev* **65**, 451-458.
2. Hughes CF, Ward M, Hoey L *et al.* (2013) Vitamin B12 and ageing: current issues and interaction with folate. *Ann Clin Biochem* **50**, 315-329.
3. Russell RM (2001) Factors in aging that effect the bioavailability of nutrients. *J Nutr* **131**, 1359s-1361s.
4. Hill TR, Aspray TJ, Francis RM (2013) Vitamin D and bone health outcomes in older age. *Proc Nutr Soc* **72**, 372-380.
5. Inzitari M, Doets E, Bartali B *et al.* (2011) Nutrition in the age-related disablement process. *J Nutr Health Aging* **15**, 599-604.
6. Department of Health: Committee on Medical Aspects of Food Policy (COMA) (1991) *Report on Health and Social Subjects 41: Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. London: The Stationery Office.
7. McCormick DB (2012) Vitamin/trace mineral supplements for the elderly. *Adv Nutr* **3**, 822-824.
8. Bates CJ, Prentice A, Cole TJ *et al.* (1999) Micronutrients: highlights and research challenges from the 1994-5 National Diet and Nutrition Survey of people aged 65 years and over. *Br J Nutr* **82**, 7-15.
9. Roman Vinas B, Ribas Barba L, Ngo J *et al.* (2011) Projected prevalence of inadequate nutrient intakes in Europe. *Ann Nutr Metab* **59**, 84-95.
10. Ter Borg S, Verlaan S, Hemsworth J *et al.* (2015) Micronutrient intakes and potential inadequacies of community-dwelling older adults: a systematic review. *Br J Nutr*, 1-12.
11. Collerton J, Davies K, Jagger C *et al.* (2009) Health and disease in 85 year olds: baseline findings from the Newcastle 85+ cohort study. *BMJ* **339**, b4904.
12. Collerton J, Barrass K, Bond J *et al.* (2007) The Newcastle 85+ study: biological, clinical and psychosocial factors associated with healthy ageing: study protocol. *BMC Geriatr* **7**, 14.
13. Davies K, Kingston A, Robinson L *et al.* (2014) Improving Retention of Very Old Participants in Longitudinal Research: Experiences from the Newcastle 85+ Study. *PLoS One* **9**, e108370.
14. Nelson M, Atkinson M, Meyer J (1997) *A Photographic Atlas of Food Portion Sizes.* London: Ministry of Agriculture, Fisheries and Farming (MAFF) Publications.
15. Food Standards Agency (2002) *McCance and Widdowson's The Composition of Foods, Sixth summary edition.* Cambridge: Royal Society of Chemistry.
16. Mendonça N, Hill TR, Granic A *et al.* (2016) Macronutrient intake and food sources in the very old: Analysis of the Newcastle 85+ Study. *Br J Nutr* 115(12):2170-2180.
17. Chandola T, Jenkinson C (2000) The new UK National Statistics Socio-Economic Classification (NS-SEC); investigating social class differences in self-reported health status. *J Public Health Med* **22**, 182-190.
18. Innerd P, Catt M, Collerton J *et al.* (2015) A comparison of subjective and objective measures of physical activity from the Newcastle 85+ study. *Age Ageing* **44**, 691-694.
19. Finch S DW, Lowe C, Bates CJ, Prentice A, Smithers G, Clarke PC. (1998) *National Diet and Nutrition Survey: people aged 65 years and over - Report of the diet and nutrition survey*. London: The Stationery Office.
20. European Prospective Investigation of Cancer (2015) The EPIC-Oxford Study. http://www.epic-oxford.org/ (accessed 15/01/2015)
21. Bates B, Lennox A, Prentice A *et al.* (2014) National Diet and Nutrition Survey Years 1-4 (combined) (2008/2009-2010/12) - Appendices and Tables. https://www.gov.uk/government/statistics/national-diet-and-nutrition-survey-results-from-

years-1-to-4-combined-of-the-rolling-programme-for-2008-and-2009-to-2011-and-2012 (accessed August 2015)
22. Scientific Advisory Committee on Nutrition (SACN) (2015) *Draft Vitamin D and Health report*. Public Health England.
23. Veronese N, Berton L, Carraro S *et al.* (2014) Effect of oral magnesium supplementation on physical performance in healthy elderly women involved in a weekly exercise program: a randomized controlled trial. *Am J Clin Nutr* **100**, 974-981.
24. Chacko SA, Song Y, Nathan L *et al.* (2010) Relations of dietary magnesium intake to biomarkers of inflammation and endothelial dysfunction in an ethnically diverse cohort of postmenopausal women. *Diabetes Care* **33**, 304-310.
25. Orchard TS, Larson JC, Alghothani N *et al.* (2014) Magnesium intake, bone mineral density, and fractures: results from the Women's Health Initiative Observational Study. *Am J Clin Nutr* **99**, 926-933.
26. Semba RD, Ricks MO, Ferrucci L *et al.* (2009) Low serum selenium is associated with anemia among older adults in the United States. *Eur J Clin Nutr* **63**, 93-99.
27. Ray AL, Semba RD, Walston J *et al.* (2006) Low serum selenium and total carotenoids predict mortality among older women living in the community: the women's health and aging studies. *J Nutr* **136**, 172-176.
28. Granic A, Aspray T, Hill T *et al.* (2014) 25-hydroxyvitamin D and increased all-cause mortality in very old women: the Newcastle 85+ study. *J Intern Med*.
29. Granic A, Hill TR, Kirkwood TB *et al.* (2015) Serum 25-hydroxyvitamin D and cognitive decline in the very old: the Newcastle 85+ Study. *Eur J Neurol* **22**, 106-115, e106-107.
30. Smith SR, Klotman PE, Svetkey LP (1992) Potassium chloride lowers blood pressure and causes natriuresis in older patients with hypertension. *J Am Soc Nephrol* **2**, 1302-1309.
31. Alam S, Johnson AG (1999) A meta-analysis of randomised controlled trials (RCT) among healthy normotensive and essential hypertensive elderly patients to determine the effect of high salt (NaCl) diet of blood pressure. *J Hum Hypertens* **13**, 367-374.
32. Strazzullo P, D'Elia L, Kandala N-B *et al.* (2009) Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ* **339**.
33. Scientific Committee on Food, Scientific Panel on Dietetic Products Nutrition and Allergies (2006) Tolerable upper intake levels for vitamins and minerals. Parma, Italy: European Food Safety Authority.
34. Scientific Advisory Committee on Nutrition (SACN) (2005) *Review of Dietary Advice on Vitamin A*. London: The Stationery Office.
35. Darmon N, Drewnowski A (2008) Does social class predict diet quality? *Am J Clin Nutr* **87**, 1107-1117.
36. Novakovic R, Cavelaars A, Geelen A *et al.* (2014) Socio-economic determinants of micronutrient intake and status in Europe: a systematic review. *Public Health Nutr* **17**, 1031-1045.
37. Jones NR, Conklin AI, Suhrcke M *et al.* (2014) The growing price gap between more and less healthy foods: analysis of a novel longitudinal UK dataset. *PLoS One* **9**, e109343.
38. Aggarwal A, Monsivais P, Cook AJ *et al.* (2011) Does diet cost mediate the relation between socioeconomic position and diet quality? *Eur J Clin Nutr* **65**, 1059-1066.
39. Rao M, Afshin A, Singh G *et al.* (2013) Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open* **3**, e004277.
40. Carlson A, Frazão E (2012) *Are Healthy Foods Really More Expensive? It depends on How You Measure the Price*. EIB-96, U.S.
41. Bodor JN, Rose D, Farley TA *et al.* (2008) Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutr* **11**, 413-420.

42. Cummins S, Macintyre S (2002) “Food deserts”—evidence and assumption in health policy making. *BMJ* **325**, 436-438.
43. McKinnon L, Giskes K, Turrell G (2014) The contribution of three components of nutrition knowledge to socio-economic differences in food purchasing choices. *Public Health Nutr* **17**, 1814-1824.
44. Adamson AJ, Collerton J, Davies K *et al.* (2009) Nutrition in advanced age: dietary assessment in the Newcastle 85+ study. *Eur J Clin Nutr* **63 Suppl 1**, S6-18.
45. World Cancer Research Fund / American Institute for Cancer Research (2007) Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington DC: AICR.

Figure 1. Contribution (%) of 15 food groups to average **a**, Vitamin A; **b**, Folate; **c**, Vitamin B12; **d**, Vitamin D; **e**, Potassium; **f**, Calcium; **g**, Iron; and **h**, Selenium intake in the Newcastle 85+ Study.

Figure 2. Intake distribution and inadequacy of folate (µg) in **a**, Men and **b**, Women; of vitamin D (µg) in **c**, Men and **d**, Women; of potassium (µg) in **e**, Men and **f**, Women; of selenium (µg) in **g**, Men and **h**, Women. Horizontal dashed lines represent the LRNI, EAR and RNI for people aged 50 and over, except for vitamin D which is set for ≥65 years[6]. RNI, Reference Nutrient Intake; EAR, Estimated Average Intake; LRNI, Lower Reference Nutrient Intake.

Table 1. Health and sociodemographic characteristics of the Newcastle 85+ Study participants with complete dietary data by gender. Values are percentages (numbers)

	All	Men	Women	P-value*
Gender	793	38 (302)	62 (491)	-
Housing				0.001
Standard	78 (620)	85 (256)	74 (364)	
Sheltered	17 (137)	12 (37)	21 (100)	
Institutional	4 (34)	3 (8)	5 (26)	
Living Arrangements†				<0.001
Alone	61 (437)	42 (119)	74 (318)	
Spouse only	28 (204)	51 (145)	14 (59)	
Others	11 (79)	8 (23)	13 (56)	
Education				0.608
≤9 years	64 (501)	61 (184)	66 (317)	
10-11 years	23 (183)	25 (75)	23 (108)	
12-20 years	12 (97)	13 (39)	12 (58)	
Past-Occupation (NS-SEC)				<0.001
Higher Managerial/ Administrative/ Professional (Class 1)	34 (259)	40 (118)	31 (141)	
Intermediate (Class 2)	15 (109)	8 (23)	19 (86)	
Routine and manual (Class 3)	51 (385)	52 (155)	50 (230)	
Physical Activity				<0.001
Low	22 (176)	20 (60)	24 (116)	
Medium	44 (343)	33 (99)	50 (244)	
High	34 (270)	47 (142)	26 (128)	
Energy (MJ)	6.65 (5.49-8.16)	7.73 (6.36-9.20)	6.15 (5.09-7.25)	<0.001‡
Carbohydrate (% en)	46.8 (42.6-51.5)	46.8 (42.7-52.0)	46.8 (42.5-51.4)	0.760§
Fat (% en)	36.8 (32.0-41.8)	36.4 (31.6-41.1)	37.2 (32.2-42.2)	0.093§
Protein (% en)	15.7 (13.5-18.3)	15.9 (13.8-18.9)	15.5 (13.6-17.9)	0.006§
Dietary Supplement Use				0.252
None	58 (456)	62 (185)	55 (271)	
1	29 (227)	27 (81)	30 (146)	
2+	14 (108)	12 (35)	15 (73)	
Dietary Supplement Type				0.590
Fish and Omega-3 Oil	48 (162)	48 (56)	48 (106)	
Mineral/ Vitamin Preparations	10 (32)	8 (9)	11 (23)	
Multivitamin and/or Multimineral	12 (39)	10 (12)	12 (27)	
Other	31 (102)	34 (39)	29 (63)	

% en, percentage of energy; NS-SEC, National Statistics Socioeconomic Classification.
* Chi-squared test ($\chi 2$) for no sex difference unless otherwise stated.
† Excludes participants living in institutions.
‡ Mann-Whitney U test for no sex difference.
§ Independent t-test for no sex difference.

Table 2. Daily energy, vitamin and mineral intakes of the Newcastle 85+ Study participants by gender and per 1 MJ of energy*

Micronutrients	All		Men			Women			
	Median	IQR	Median	IQR	Median/ 1 MJ	Median	IQR	Median/ 1 MJ	P-value‡
Energy (MJ)†	6.65	5.49-8.16	7.73	6.36-9.20	-	6.15	5.09-7.25	-	<0.001
Vitamins									
Vitamin A (μg RE)	620	398-910	674	414-988	86.5	593	390-851	98.5	0.008
β-Carotene (μg)	1516	517-2883	1769	606 -3167	212.5	1335	488-2666	215.0	0.577
Vitamin B2 (mg)	1.5	1.2-1.9	1.7	1.3-2.1	0.22	1.4	1.1-1.8	0.23	0.138
Vitamin B6 (mg)	1.7	1.2-2.1	2.0	1.5-2.5	0.25	1.5	1.1-1.9	0.25	0.217
Folate (μg)	208	157-264	245	183-295	30.9	189	146-243	31.7	0.564
Vitamin B12 (μg)	2.9	1.9-4.4	3.4	2.2-5.2	0.46	2.6	1.6-3.9	0.42	0.047
Vitamin E (mg)	4.7	3.2-7.5	5.0	2.4-8.3	0.65	4.5	2.9-6.9	0.69	0.128
Vitamin C (mg)	56.5	30.5-99.1	55.5	32.4-98.4	7.10	57.2	30.0-99.4	9.27	0.001
Vitamin D (μg)	2.0	1.2-6.5	2.3	1.4-3.7	0.33	1.8	1.0-2.9	0.30	0.200
Minerals									
Calcium (mg)	731	554-916	829	634-1007	103.7	683	537-862	111.2	0.008
Iron (mg)	8.7	6.7-11.6	10.5	8.4-13.5	1.35	7.8	6.1-9.9	1.28	0.005
Magnesium (mg)	215	166-266	251	196-309	32.6	196	156-239	32.4	0.316
Potassium (mg)	2477	1890-3023	2798	2230-3448	356.6	2262	1804-2797	373.4	0.100
Sodium (mg)§	2388	1829-3188	2987	2216-3743	372.1	2162	1691-2707	361.6	0.101
Selenium (μg)	39.0	27.3-55.5	48.3	33.9-65.1	6.19	35.2	25.3-48.4	5.83	0.028
Zinc (mg)	7.1	5.5-9.6	8.6	6.8-11.1	1.12	6.3	5.1-8.2	1.05	<0.001

IQR, Interquartile Range; RE, Retinol Equivalents.
* Does not include supplements.
† Does not include energy from alcohol.
‡ Mann-Whitney U test for no sex difference (Median/ 1 MJ of energy).
§ Does not include table salt and salt used for cooking.

Table 3. Daily energy, vitamin and mineral intakes according to demographic, socioeconomic and lifestyle characteristics†

Micronutrients	Housing			Live With			Education (years)			Past-Occupation (NS-SEC)			Physical Activity		
	Stand (n=620)	Sheltered (n=137)	Institut (n=34)	Alone (n=437)	Spouse (n=204)	Others (n=79)	≤9 (n=501)	10-11 (n=183)	≥12 (n=97)	Class 1 (n=385)	Class 2 (n=109)	Class 3 (n=259)	Low (n=176)	Medium (n=343)	High (n=270)
Energy (MJ)‡	6.62	6.78	7.65*	6.36	7.28	6.64	6.57	6.69	6.89	6.76	6.63	6.64	6.77	6.37	6.92
Vitamins															
Vitamin A (µg RE)	606	623	709	600	642	582	602	625	667	639	636*	600	627	599	648
β-Carotene (µg)	1589	1093	1546	1381	1792	1365	1492	1493	1470	1575	1576	1339	1382	1339	1730
Vitamin B2 (mg)	1.5	1.5	1.8	1.4	1.6	1.4	1.5	1.6	1.7	1.6**	1.5*	1.5	1.6	1.4	1.6
Vitamin B6 (mg)	1.7	1.6	1.7	1.6	1.9	1.6	1.6	1.7	1.8	1.7	1.7	1.6	1.5	1.6*	1.9***
Folate (µg)	208	195	231	195	231	191	201	209	234	214*	208	203	185	201	232**
Vitamin B12 (µg)	2.9	2.7	3.8	2.7	3.1	2.2	2.8	3.1	3.0	3.0	2.8*	2.8	3.0	2.5	3.2
Vitamin E (mg)	4.7	4.7	3.9*	4.7	4.8	4.6	4.7	4.7	5.1	4.7	5.2	4.5	4.5	4.4	5.2*
Vitamin C (mg)	59.0	49.6	62.1	55.2	56.7	62.3	54.8	55.5	80.0**	61.7	64.5	52.1	46.6	56.4	66.6*
Vitamin D (µg)	1.9	1.9	3.5**	1.8	2.1	1.9	1.9	2.1*	2.1*	2.0	1.9	1.9	2.6	1.8*	2.1
Minerals															
Calcium (mg)	730	731	736	713	799	638*	710	738	778*	753*	730	722	735	702	771
Iron (mg)	8.9	8.0***	9.0	8.3	9.8	7.9	8.3	9.6	9.9	9.3**	8.7	8.6	8.6	8.4*	9.5**
Magnesium (mg)	220	205**	195***	209	236	196	211	216.	235**	226***	223***	209	197	208***	235***
Potassium (mg)	2504	2445*	2363**	2348	2738*	2276	2397	2495	2904**	2656***	2440	2402	2278	2381**	2725***
Sodium (mg)§	2357	2482*	2678	2363	2532	2077*	2351	2464	2390	2381	2363	2392	2401	2285*	2573
Selenium (µg)	39.1	36.2	41.5	37.9	40.8*	34.0	38.1	40.0	39.0	38.1	39.7*	39.3	37.8	38.1	41.1
Zinc (mg)	7.2	7.0	7.4	6.9	7.9	6.2	7.0	7.3	7.6	7.4**	7.2*	7.0	7.0	6.7	8.0*

NS-SEC, National Statistics Socioeconomic Classification; Stand, Standard; Institut, Institutional Housing; Class 1: Higher managerial, administrative and professional occupations; Class 2: Intermediate occupations; Class 3: Routine or manual occupations.

All models were adjusted for gender and energy intake except for energy intake which was only adjusted for gender. Standard housing, living alone, ≤9 years of full time education, class 3 of past occupation and low physical activity were the reference categories.

* $p<0.05$ ** $p<0.01$*** $p<0.001$.

† Does not include supplements.

‡ Does not include energy from alcohol.

§ Does not include table salt and salt used for cooking.

Supplementary Table 1. Daily vitamin and mineral intakes from all sources (including supplements) and, the difference (%) between dietary sources only (excluding supplements) in the Newcastle 85+ Study participants by gender

Micronutrients	All			Men				Women			
	Median	IQR	Dif (%)	Median	IQR	Median/ 1MJ	Dif (%)	Median	IQR	Median/ 1 MJ	Dif (%)
Vitamins											
Vitamin A (μg RE)	752	462-1255	19.2	801	479-1281	104	17.2	711	450-1243	116	18.1
Vitamin B2 (mg)	1.6	1.2-2.0	6.5	1.7	1.3-2.2	0.2	0.0	1.4	1.1-1.9	0.2	0.0
Vitamin B6 (mg)	1.7	1.3-2.2	0.0	2.0	1.5-2.5	0.3	0.0	1.6	1.2-2.0	0.3	6.5
Folate (μg)	212	158-276	1.9	247	186-300	32	0.8	193	147-253	31	2.1
Vitamin B12 (μg)	3.0	1.9-4.6	3.4	3.5	2.2-5.4	0.5	2.9	2.6	1.6-4.1	0.4	0.0
Vitamin E (mg)	5.0	3.3-8.2	6.2	5.3	3.5-8.6	5.8	5.8	4.9	3.1-7.9	0.8	8.5
Vitamin C (mg)	60.5	31.7-110.3	6.8	57.7	35.1-108.8	0.7	3.9	62.4	31.2-112.2	10.2	8.7
Vitamin D (μg)	2.5	1.3-6.2	22.2	2.7	1.6-6.3	0.4	16.0	2.3	1.2-6.2	0.4	24.4
Minerals											
Calcium (mg)	735	555-922	0.5	833	640-1008	104	0.5	691	538-868	112	1.0
Iron (mg)	8.9	6.8-11.8	2.3	10.6	8.3-13.7	1.4	1.0	7.9	6.2-10.2	1.3	1.3
Magnesium (mg)	218	169-269	1.1	254	200-312	33	1.3	198	157-247	33	0.6
Selenium (μg)	39.4	27.6-57.5	1.0	49.2	34.4-67.9	6.4	1.9	35.7	25.4-50.1	5.9	1.4
Zinc (mg)	7.3	5.7-9.9	2.7	8.7	7.0-11.7	1.1	1.2	6.6	5.3-8.7	1.1	4.7

IQR, Interquartile Range; RE, Retinol Equivalents; Dif, difference between median vitamin and mineral intakes from all sources (including supplements) and dietary sources only.
There is no β-carotene and sodium supplementation use.

Supplementary Table 2. Percentage (%) of the Newcastle 85+ Study participants below the RNI, EAR and LRNI for the UK by gender*

Micronutrients	All			Men			Women			P-value†
	<LRNI	<EAR	<RNI	<LRNI	<EAR	<RNI	<LRNI	<EAR	<RNI	
Vitamins										
Vitamin A (μg RE)	10.5	28.1	51.7	13.1	31.9	52.3	8.8	25.8	51.3	0.786
Vitamin B2 (mg)	6.8	10.9	26.0	3.6	11.4	23.5	8.8	9.9	27.5	0.214
Vitamin B6 (mg)	-	-	27.1	-	-	20.9	-	-	31.0	0.002
Folate (μg)	3.4	22.1	46.4	1.3	13.5	30.3	4.7	27.4	56.4	<0.001
Vitamin B12 (μg)	9.6	13.6	17.5	5.0	8.0	9.9	12.4	17.1	22.2	<0.001
Vitamin C (mg)	4.2	19.0	34.1	2.6	17.4	30.5	5.1	20.0	36.3	0.095
Vitamin D (μg)	-	-	95.3	-	-	94.4	-	-	95.9	0.313
Minerals										
Calcium (mg)	5.7	19.4	44.6	3.3	14.8	31.9	5.7	22.3	52.6	<0.001
Iron (mg)	5.7	25.0	49.6	2.3	4.4	29.6	7.8	33.3	62.0	<0.001
Magnesium (mg)	22.1	51.3	81.3	22.2	50.0	71.2	22.0	52.1	87.6	<0.001
Potassium (mg)	30.0	-	87.5	18.9	-	77.2	36.9	-	93.9	<0.001
Sodium (mg)‡	0.0	-	17.8	0.0	-	10.9	0.0	-	22.0	<0.001
Selenium (μg)	52.7	-	85.9	37.5	-	83.6	62.2	-	87.3	0.145
Zinc (mg)	10.2	32.0	60.3	11.2	31.6	60.9	9.6	32.3	59.2	0.625

RNI, Reference Nutrient Intake; EAR, Estimated Average Intake; LRNI, Lower Reference Nutrient Intake; RE, Retinol Equivalents.
RNI, EAR and LRNI were taken from the UK dietary reference values for people aged 50 and over, except for vitamin D which is set for older adults[6].
* Does not include supplements.
† Chi-squared test ($\chi 2$) for no sex difference in percentage below RNI.
‡ Does not include table salt and salt used for cooking.

Figure 1. Contribution of food groups (%) to micronutrient intake in the Newcastle 85+ Study participants

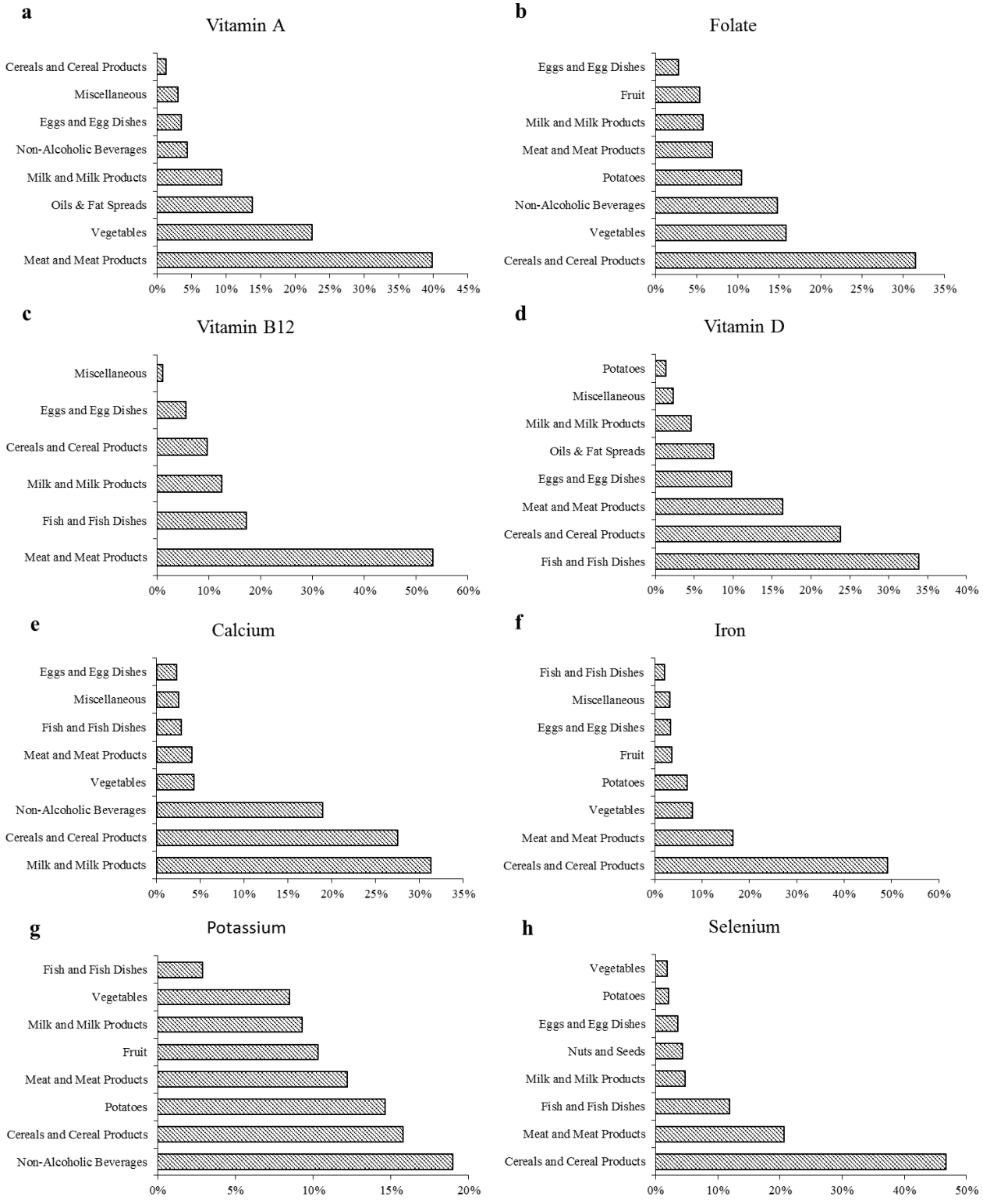

Figure 2. Intake distribution and inadequacy of folate, vitamin D, potassium and selenium in the Newcastle 85+ Study participants by gender